ENVIRONMENTAL PROTECTION

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DESIGNING ASPIRATION SYSTEMS FOR BATCH-PREPARING DIVISIONS OF GLASS FACTORIES

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The most widely used types of dust-collecting equipment for batch-preparing divisions of glass factories are considered and the aspiration systems designed by the Stromizmeritel' JSC are described.

Batch-preparing divisions of glass factories perform treatment of raw materials and prepare batches for glass melting. The equipment used in the treatment and transportation of raw materials and batch preparation is a source of dust and polluting agents; therefore, certain measures have to be taken to protect the personnel, machinery, and the ambient environment.

The Stromizmeritel' JSC carries out designing, supply of machinery, and "turn-key" installation of aspiration systems for the construction of new ones or upgrade of existing batch-preparing divisions. The design of aspiration systems is carried out together with automation and air supply and power supply systems, which allows for an integrated solution of the problem of dust removal.

The main methods for decreasing dust generation in batch-preparing divisions is sealing the technological equipment, the sites of reloading batch and its components, and other places where a dust-air mixture is generated, as well as installing aspiration systems using up-to-date purifying equipment.

The separation of dust particles from gas is performed in different ways: by precipitation under the effect of gravity and inertia (dust-collecting chambers, louver dust collectors, cyclones, etc.); moistening dust with liquid and its removal in the form of slime (wet dust collectors); precipitation on electrodes under the effect of electricity (electric filters); filtration via a porous membrane that retains dust (bag filters).

Cyclones are inertia-type dust collectors [1]. Their principle of action is as follows. The dust-air mixture is supplied to the cylindrical part of a cyclone at a tangent to the inner surface of the pipeline and in sinking aquires a rotary motion. During the rotation of the current, centrifugal forces arise and make the particles move toward the surface of the cyclone and settle on it, sinking in a spiral motion to the conical part and discharging through the pipeline. The gas purified from dust goes to the central part of the cyclone and is released upwards through the pipe.

There are two types of cyclones: with tangential supply of gas flow and with axial supply. The precipitation velocity in cyclones with the axial supply of dust-laden gas depends on the design of the guiding device. The gas flow in this case first changes direction and then acquires a rotary motion, which creates additional resistance. More common in practice are cyclones with tangential gas supply. The batch-preparation divisions of glass factories most frequently use cyclones TsN-11, TsN-15, TsN-24, and SKTsN-34, as well as cyclones with a twisted counterflow [2]. The Stromizmeritel' JSC uses TsN-15 cyclones as the first stage in purifying flue gases coming from drying drums. To purify a substantial amount of gas and to increase the degree of purification, small-radius cyclones are grouped in multiclones. Cyclones and multiclones can be successfully used to collect relatively coarse dust particles (over 10 μm). The efficiency of the cyclone in this case reaches 98%. Collecting finer dust is not efficient, since the efficiency does not exceed 30 – 50%. Most frequently cyclones are used for preliminary purification. Finer dust can be better collected by electric filters and bag filters, which should be recommended for this purpose.

Textile filters are used for fine dust collection and as a second stage after the cyclones. Highly efficient (the degree of purification from 99.00 to 99.99%) compact textile filters are extensively used now. There are various types of textile filters: those working under the pressure of an incoming dust-gas mixture (pressure filters); those working under rarefaction, when a fan or a smoke exhauster is placed after the filter. The operating principle of textile filters is based on the fact that dust-laden gas is transmitted through a porous mem-

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brane, on which the dust layer is retained, whereas air passes through the pores. After a layer of dust is accumulated on the membrane, the feed of the dust-air mixture stops, the dust is shaken off the filter, then the feed of the dust-air mixture is resumed, and the operation continues. Filter membranes are often made from different types of tissues in the form of bags stretched over frames. Hence the name of the bag (textile) filters. Bag frames can have different shapes: round, elliptical, star-shaped, etc. There are cartridge filters as well. The filtering membrane in the latter is a cartridge with a corrugated surface whose area is several time larger then the surface area of the bag.

At the initial moments of filtration, large dust particles settle on the filtering membrane, since their size is larger than that of the pores in the fabric, whereas fine particles settle later due to their collision with filaments and fibers of the membrane. In further operation a layer of dust is formed on the surface of the fabric, and gas has to penetrate through this layer passing through finer channels and settling in the form of finer dust. With time the dust layer increases, and the filter efficiency decreases. When the hydraulic resistance reaches a certain value, the filter is switched over to the regeneration mode (cleaning the deposited dust by shaking). The regeneration system works automatically ensuring timely purification from dust and maintaining the rated gas permeability in the filtering elements. If the regeneration process is not sufficiently effective, the hydraulic resistance of the filter increases and the flow rate of the polluted gas decreases. At the same time, under excessive purification a greater amount of dust penetrates through the fabric, since the external side of the filtering element becomes too "naked," i.e., the thickness of the filtering layer becomes perceptibly smaller. Therefore, in the course of filter operation the most effective parameters of the system are selected experimentally. For this purpose the regeneration system contains elements providing for tuning its efficiency under different service conditions.

Contemporary textile filters use two methods for the regeneration of filtering elements: compressed air pulse blowing and vibration.

The pulse regeneration system uses compressed air that periodically comes in pulses into filters which are shaken and blown. The hydraulic resistance, i.e., the pressure difference between the clean chamber and the filtering element space (this pressure difference is the controlling factor in the regeneration system), is the main parameter monitored in the filter service. The differential manometer constantly measures the pressure difference and, upon reaching a preset value (specified on the dial), a signal is transmitted to the controller, which, in accordance with the program, starts the pulse valves. More usual is the variant where the controller keeps giving commands to switch on the pulse and shut-off valves with a preset interval. The differential manometer works as an indicator and helps to choose a correct time interval between the pulses. In this mode the time interval is the tuning parameter.

In vibration shaking filtering elements are purified using an electromechanical vibrator. The advantage of this method is that vibration filters can be used in places that do not have compressed air or where this air is not dry enough to be used in nonheated rooms and in open places. This purification method involves only periodical short-term cleaning of the filter. This restricts the use of vibration filters to the following cases: when a hopper or a silo is filled by pneumatic transport, the filter can be cleaned only after the material is pumped in; when the filter is used with an exhaust fan, the filtering elements can be cleaned only after the full stop of the fan.

Textile filters use filtering elements of two types: woven fabrics and nonwoven cloth made from different natural and synthetic fibers. Cloth made of synthetic fiber has lately become the most common filtering material. Filtering materials made of synthetic polyester, polypropylene and high-temperature fiber such as oxalon, metaaramide, polyphenyl sulfide, and polyamide effectively function at low as well as at high temperatures (up to 290°C) and have the following advantages:

– long service life — warranty up to 3 years under corresponding service conditions;

– high mechanical, chemical, and temperature resistance;

– high filtration efficiency; for instance after capturing finely dispersed particles of size below 1 μm the residual dust content is 0.02 g/m^3 ;

– good regenerating capacities.

In addition to the above listed fabrics, filters can be made of nonwoven cloth based on synthetic fibers (needle-perforated felt). The felts have high resistance to multiple folding, and they are subjected to thermal and mechanical treatment to obtain a smooth surface. The application of felt makes it possible to increase the gas filtration rate 2 – 5 times.

In the service of textile filters, it is especially important to maintain the admissible temperature intervals in purified gases. If that temperature is exceeded, the service life of the fabric decreases, and the filter bag is more brittle and quickly becomes unfit for service and loses tits filtering properties. The lower limit of gas temperature should be 10°C above the dew point. Otherwise there is a risk of dust sticking to the bag surface wetted by the condensed moisture. The pores of the tissue becomes clotted, the hydraulic resistance sharply grows, and further service of the filter as a rule become impossible. Therefore, compressed air used to regenerated filtering elements has to be dried, and the dust-gas mixture subjected to purification should have a temperature 10°C above the dew point.,

By way of example we can consider the purification of flue gases from drying drums. As the moisture content in waste flue gases is rather high, the temperature of the gas should be maintained above 110°C. Furthermore, in practice when for different reasons there is a deviation from the drying technology, the material arriving from the drying drum

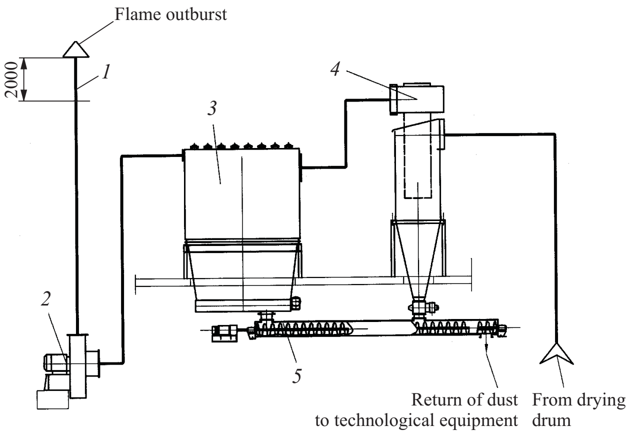

Fig. 1. Scheme of dust collection from flue gas generated by the drying drum: *1*) roof; *2*) smoke exhauster; *3*) bag filter, *4*) cyclone TsN-15; *5*) screw conveyor.

for further processing (crushing, screening) may have high moisture and an increased temperature, as it has no time to cool. In this case we recommend using a filtering material with a hydrophobic finish or a Teflon coating, which prevents the penetration of dust particles inside the material and clotting of pores.

The two-stage variant of purification (cyclone + filter) of flue gases from a drying drum used in projects designed by Stromizmeritel' JSC is shown in Fig. 1. This design includes a filter produced by the Space-Motor JSC (St. Petersburg). The filter has good technical characteristics, a high degree of purification (for an input dust content up to 20 g/m^3 the output dust content is not more than 10 mg/m^3), and a design convenient for maintenance: the filter elements are serviced through the lateral wall, which is different from the filters made by other Russian producers.

The high degree of purification of contemporary filters providing for a low residual dust content (up to 5 mg/m^3) makes it possible to released the purified air directly into the workshop.

The Stromizmeritel' JSC uses filters of known foreign manufacturers for its designs, such as INFASTAUB (Germany) and WAM S.p.A. (Italy). Compact sizes, a wide range of standard sizes, different variants of accessories, and the fixation of the fan on the filter body make it possible to install these filters directly on technological machinery without an air conduit (Fig. 2*a*). Such layout is especially convenient in a constrained space, since one can avoid a network of pipelines encumbering the interior of the workshop. The same filters can be arranged in a different way, allowing for a connection with an air conduit (Fig. 2*b*). In this case the quantity of required filters can be decreased.

Since air purified in such filters can be released directly into the workshop, there is no need to have air-inflow chambers compensating for the air that is released into the atmosphere by the aspiration systems. Only the flue gas from the drying drum after dust collection has to be released into the

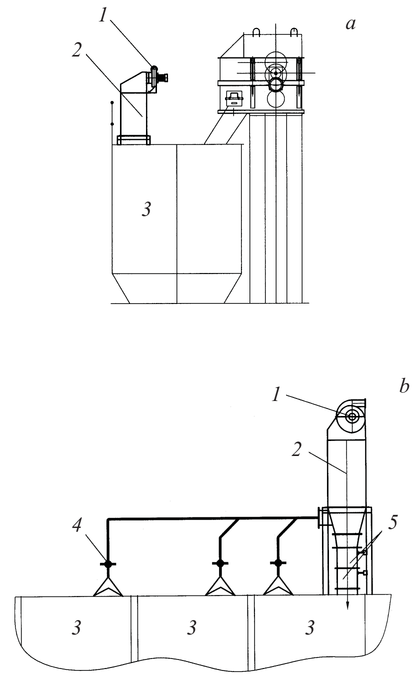

Fig. 2. Variants of filter installation without a system of air conduits (*a*) and with air conduits (*b*): *1*) fan; *2*) bag filter; *3*) hopper; *4*) disc gate with pneumatic drive; *5*) "Migalka" gate.

atmosphere, since, besides the dust component, it contains the products of natural gas combustion.

A way for decreasing the dust content is the use of pneumatic transport for feeding material in batch-preparing division. This is the most airtight method for material transportation, which makes it possible to bring the dust content in the work zone to the maximum admissible value. To prevent dusting in silos or hoppers loaded with pneumatic transport, one can use pressure filters, as well as rarefaction filters equipped with fans. Since the pressure filter has no fan, its cost and electricity consumption are lower than those of the filter with a fan. In other cases when the containers under loading are not airtight enough or when charging is performed by two methods (pneumatic and mechanical charging), the use of a filter with a fan is justified. In this case a small rarefaction is developed inside the container that is being loaded, which prevents the penetration of dust into mechanical loading equipment (elevator, conveyor) through loose sites or in a counterflow. Furthermore, it is recommended to install an emergency pressure-relief valve on silos or hoppers, This device ensures a constant pressure level in silos, bringing it in accordance with the atmospheric pressure both in the case of rarefaction arising at the moment when the material flows out of the silo and in the case of excessive air pressure during the loading of the silo. Thus, the pressure-relief valve makes it possible to avoid possible emergencies.

The development of new upgraded dust-collecting equipment and upgrade of existing dust-collecting systems significantly improves the sanitary state of the batch-preparing di-

vision at a glass factory and protects the atmospheric air from pollution. However, aspiration is an expensive activity. Therefore, the improvement of the process and the development of new technologies and equipment decreasing polluted emissions into the atmosphere and thus reducing the number of aspiration systems are cost-effective processes and constitute one of the main sectors in the activity of the Stromizmeritel' JSC.

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